

Tiered Storage Economics

Defining and Calculating the Economic Benefit of
Dynamic Tiered Storage Solutions

White Paper

By David R. Merrill

April 2008



Executive Summary

As IT architects and storage planners continue to look at best practices and technologies to proactively reduce ownership costs, dynamic tiered storage solutions should be part of a short- and long-term strategy for improved asset utilization and storage efficiencies. While many IT planners assume that purchasing low-cost disk solutions alone will drive down the total cost of storage ownership, Hitachi Data Systems has observed that price alone cannot sufficiently impact lowering of operating expenses or reducing the total cost of disk ownership. Properly designing and implementing dynamic, multitiered storage architectures can significantly reduce current and long-term total cost of ownership

This paper examines trends and empirical results by Hitachi Data Systems consultants and IT analysts, which indicate that providing multiple tiers of storage to meet multiple lifecycle demands can have a positive impact on return on investment (ROI) and reductions in capital and operating expense. Business and technical values of providing mobility of the data between the tiers is an essential characteristic in today's high-growth and complex storage infrastructures.

The potential to lower storage-related operating costs (OPEX) over three years with tiered storage has been measured at 15 to 30 percent, when compared to a single-tiered architecture. This paper characterizes cost-savings areas, calculation methods and proofs related to reducing labor, cost of growth (capital expense or CAPEX), the cost of storage waste, software licenses and infrastructure with a dynamic, tiered storage architecture.



Contents

Introduction	1
Tiered Storage Foundations	3
Data Characterization	5
Intermix versus Virtualized Storage for a Tiered Architecture	6
Dynamic Multitiered Storage and Storage Economics	6
TCO Reduction and Calculation Details of Tiered Storage	7
Lower Cost of Growth	7
Sweat the Assets	10
Improving Aggregate Utilization	10
Calculating Potential Cost of Waste	11
Reducing Labor Cost.....	11
Data Protection/Disaster Protection	12
Conclusion	13
Appendix A: Sample Tiered Storage Architecture	15

Tiered Storage Economics

Defining and Calculating the Economic Benefit of Dynamic Tiered Storage Solutions

White Paper

By David R. Merrill

Introduction

Many IT planners make the mistake of assuming that purchasing low-cost disk solutions will drive down the total cost of ownership (TCO) for storage, but Hitachi Data Systems has observed that price alone does not equate to reducing the total cost of disk ownership. Hitachi Data Systems consultants and IT analysts see trends, which indicate that purchasing only cheaper disk solutions to reduce short-term capital expense (CAPEX) can often produce a negative long-term impact on operating expense (OPEX). The purchase price of disk hardware represents only 20 to 25 percent of the TCO (TCO-per-TB/unit per Year) for the storage infrastructure. As the price of disk continues to decline (and approaches zero), other methods besides lowering CAPEX have to be explored to impact multiyear costs of storage ownership. There are methods to incorporate cheaper disk technology into a comprehensive tiered storage architecture that can effectively reduce both capital and operating expense, while providing the levels of service necessary in today's complex and evolving storage infrastructures.

Hitachi Data Systems has developed a series of papers, methods, tools and service offerings around storage economics, which is the study and practices to reduce operating expense costs from storage infrastructures. One of the activities documented in this methodology — as addressed in “Storage Economics: Identifying and Reducing Operating Expenses in the Storage Infrastructure” (<http://www.hds.com/assets/pdf/StorageEconomicsWHP-153.pdf>)— to significantly reduce the TCO is tiered storage. Dynamic tiered storage enables data and applications to be stored on tiers that vary in performance, cost, availability, recoverability, etc. Tiers of storage can segment costs, reduce waste, provide cheaper entry costs and add agility to responding to unforecast growth. Tiered storage, when properly designed and implemented, can be managed as effectively as a single-tiered architecture, with tools that can move, migrate and respond to aging and migration needs of the data/application.

As a definition, tiered storage is not simply storing data on various storage systems by different vendors, each having separate operating consoles and functions. Dynamic multitiered storage implies a single-image pool of storage, with integrated but segmented storage tiers, all controlled by unified storage architecture. Data can be promoted or demoted seamlessly through the tiers. Optimization of storage to applications and business users is enabled and essential. Multiple products and vendors may be included in the technical architecture, but the storage pools are abstracted above the individual storage systems. Some level of virtualization is implied within multitiered storage.

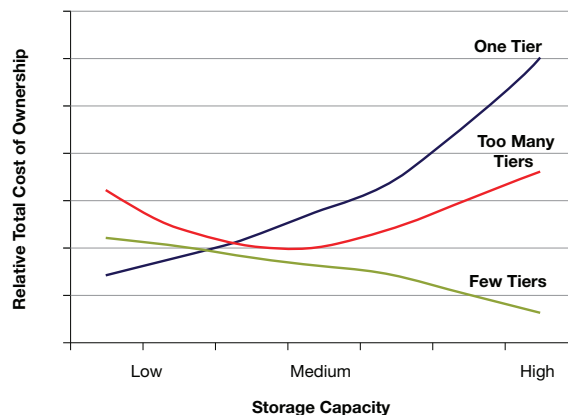
This paper defines how dynamic, multitiered storage can be used to effectively reduce OPEX and CAPEX costs from the storage infrastructure. Other technical, operational and organization benefits do certainly exist, but are not extensively included in this work. Additionally, there are predecessor activities that may be necessary before embarking on a multitiered storage strategy; again, these implementation and planning activities are not included in this work. IT planners need to ensure that the storage network infrastructure, operating processes and application knowledge are in place so that a tiered architecture can be implemented in order to reduce costs. An economic impact study on tiered storage alternatives may be a useful mechanism to evaluate several new storage architectures and implementation options.

This paper describes the economic superiority of dynamic tiered architecture. Building and growing with tiered silos, with limited data mobility between the tiers, may achieve some of the economic benefits outlined in this paper, but the propagation of stranded capacity and data isolation does not provide the full TCO benefits of a dynamic tiered architecture. Achieving a dynamic architecture requires the addition of storage virtualization into the recipe to achieve superior cost results.


Over several years of work looking at tiered storage architecture (both integrated and ad hoc), Hitachi Data Systems consultants have derived the following economic conclusions around dynamic tiered storage:

- Over three years time, dynamic multitiered storage on average demonstrates 15 to 30 percent lower TCO than a single-tiered architecture.
- Some examples of tiered environments suggest that this architecture can increase the cost of labor, since the management efforts require more sophisticated management, skills and infrastructure. We often find that a higher storage management maturity is necessary in deploying and optimizing dynamic tiered storage. There is clearly a crossover point that is to be defined in each IT organization relating to the possible increase in tiered management complexity and the resulting OPEX and CAPEX reductions achieved with dynamic tiered storage.
- Not only can storage be tiered, but other areas of the storage infrastructure can also be segmented into service tiers to optimize costs and work efforts, according to service level agreements (SLAs). The other storage infrastructure areas that can be tiered include:
 - Backup services (disk-to-tape, disk-to-disk, virtual tape)
 - Storage network connections (Fibre Channel, iSCSI, network attached storage [NAS])
 - Disaster recovery services (synchronous, asynchronous copies)
 - Data protection services (snap copies, mirroring)
- There is a “sweet spot” relative to the number of tiers and the cost-effectiveness of multitiered storage architecture. IT groups that create too many tiers may actually increase the cost and complexity of the new architecture. Hitachi Data Systems tends to see the multitiered storage sweet spot within three to four tiers of storage.
- There is crossover point relative to cost and total capacity. Figure 1 shows that a single-tiered approach may be most cost-effective for lower aggregate capacities, but as growth increases the total cost leader becomes a multitiered architecture.

Figure 1. Comparing Tiers, Total Capacity and Total Ownership Costs



A single-tiered approach may be most cost-effective for lower aggregate capacities, but as growth increases the total cost leader becomes multitiered storage.



Recent advancements in storage intermix (the mixing of different type types and capabilities in the storage system) also extend the economic and business value of a tiered storage strategy.

Tiered Storage Foundations

Before we dive into the economic factor of dynamic tiered storage, we will define some basic tiered storage foundation principles to assist in building the economic value propositions detailed in this paper. The basic concepts and benefits of tiered storage and services oriented storage solutions are as follows:

- Data and storage requirements change over time (five percent per week).
- Lifecycle and storage cycle are deterministic, based on business use and value.
- Availability, performance and value change as the data gets older.
- Not all data is created equal, or has an equal lifecycle.

Most IT departments deploy storage in one tier, and for many that one tier is an enterprise-class storage system with high-performance disk, cache, Fibre Channel or IBM® FICON® ports, etc. The aggregate cost of the single storage infrastructure can often be overkill for the value of the data and applications residing on the storage. All data is not equal; therefore, data needs to be allocated on different tiers, with different price points, different service levels and different storage technology. Having different vendors or models of storage for different servers is not tiered storage; tiered storage needs to be highly integrated with a single management console, with tools to move or repurpose storage infrastructure to meet business needs. Tiered management needs to adapt to the lifecycle (predictable or not) of the data, applications and businesses that it supports.

The concept of multitiered storage enables several improvements for operations, management and cost.

- Different storage and provisioning is available for different data.
- Different SLAs and operating level agreements (OLAs) are needed to provide different levels of:
 - Total systems availability
 - Provisioning time, mean time to allocate
 - Recoverability
 - Management and labor effort
 - SAN infrastructure
 - Backup support and infrastructure
 - Disaster protection, recoverability
 - Security, encryption
 - Operational control and monitoring
- Different growth rates can be applied to the different tiers.
- Varying purchase and ownership costs need to be applied to the different tiers.
- Tiers of storage infrastructure need to be planned for more than the HDD type. Tiering should also include:
 - Connection protocol
 - Connection paths
 - Backup frequency
 - Replication and copy instances


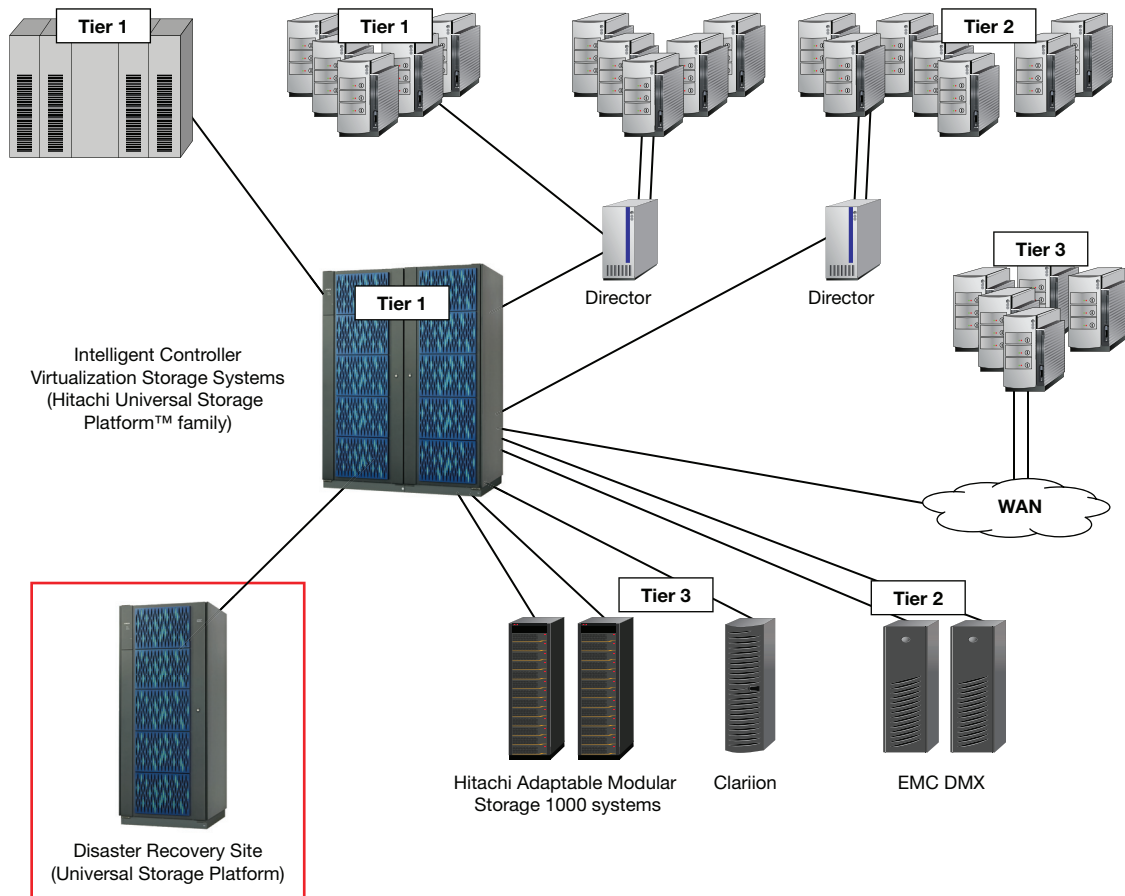


Figure 2 represents a simple tiered storage schematic and depicts how different servers, applications and data can be housed in a multitiered (integrated) architecture:

- **Tier 1 servers** as shown could be IBM MVS® or z/OS® servers, or high-end UNIX servers running business critical transactions. Connections to the storage infrastructure can be with Fibre Channel, FICON, or IBM ESCON®, and are usually dual-pathed for high availability.
- **Tier 1 storage** can consist of enterprise-class monolithic or intelligent storage systems. This disk could offer high performance, high RPM, cache, mirrored RAID protection and other features that provide high availability. In remote site data protection, recovery is usually provided for this higher-value data store.
- **Tier 2 servers** in Figure 2 could be running e-mail applications, data warehouses or other business-important transactions. These systems could be UNIX, Linux or Microsoft® Windows, etc.
- **Tier 2 storage** might be Fibre Channel-based disk, with RAID-5 protection, and either provisioned within the enterprise storage system, or virtualized into a modular class storage system. Local snap copies may exist, but remote disaster protection may not. Tier 2 storage could be employed as disaster recovery protection for Tier 1 storage.
- **Tier 3 servers** in this example are connected to a NAS or IP storage network, and may handle lower-function applications like content archive or static image files. Backup servers could be in this class as well. IP or other low-cost connection methods are used.
- **Tier 3 storage** is still managed with the same integrated tools and processes as the other tiers, but could be on high-density Serial ATA (SATA) disk with RAID-6 protection. This storage is usually very low cost, moderate to low performance and suitable as tape replacement or archive media.

Figure 2. Simple Tiered Storage Schematic



Different servers, applications and data can be housed in a dynamic, multitiered architecture.

Data Characterization

With or without sophisticated tools, organizations should be able to characterize and stratify data and storage. Most businesses can define a finite number of tiers to classify storage and data (most around three to five tiers). These data classification tiers can follow a customer-defined pattern based on how data is defined, used, aged, etc. This pattern matching results can be used to place data and application on the appropriate storage tier based on:

- Mission Critical Data
 - Most valuable to an enterprise, high access
 - High performance, high availability, near zero downtime, highest cost
- Business Critical Data
 - Important to the enterprise, average cost
 - Reasonable performance, good availability, less than eight-hour recovery
- Staged, Archive Data
 - Cost sensitive, low access, often compliance of fixed content
 - Online performance, high availability, less than eight-hour recovery
- Near line or offline Data

- Near line or offline Data
 - Cost sensitive, low access, large volumes
 - Archived data, backup or compliance related
 - Very cost sensitive, limited access, ~72 hour seek time

This paper does not define the stratification process, but it assumes that this characterization can be done. See Appendix A for a sample tiered storage feature/function design matrix.

Intermix versus Virtualized Storage for a Tiered Architecture

There is a fundamental architectural difference between integrated/dynamic tiered storage and storage intermix. Storage intermix is available from a varieties of vendors and platforms, and by definition it is the combining of different drive or protocol types into the same storage frame (SATA and Fibre Channel, or NAS and iSCSI, for example). The nature of having different drive types mixed into a single solution allows placement of data at different price points in the storage system. Nevertheless the cost and TCO savings differ somewhat with dynamic tiering and intermix due to several factors:

- Software license and maintenance fees are usually applied to a storage system and not a drive group. Low-end SATA disk inside a larger system may increase the software fees even though the data is not intended to benefit from the software.
- Overhead of cache, storage ports or management software again is applied to the entire frame, not a few LUNs or drive groups. This can be analogous to putting a trailer park in the middle of Manhattan; yes, it can be done, but the relative cost of real estate and the opportunity cost/loss does not make this a viable housing option.

Consideration of total costs versus incremental growth costs needs to be applied to an intermix TCO analysis, even though the approach may seem similar to dynamic tiering with several frames.

Dynamic Multitiered Storage and Storage Economics

The purpose of this paper is to convey best practices and OPEX cost impact Hitachi Data Systems has observed with global clients, relative to dynamic multitiered storage. The ability to store and grow the total storage demand in stratified tiers has been proven to reduce current operating and capital expenses. The economic superiority of dynamic multitiered storage architectures is summarized below.

- 1) IT planners can **avoid future storage procurement** costs by separating the rate of growth of different tiers. Moving much of the capacity growth demand to a lower or differently tiered solution reduces CAPEX costs. Multitiered growth costs are much less than single tiered growth.
- 2) **Sweat the assets** is often an important accounting initiative. With dynamic tiering the useful life of some storage assets can be extended by demoting current Tier 1 storage to a Tier 3 asset within the storage pool. Dynamic, nondisruptive movement of data and applications is enabled by storage virtualization.
- 3) **Superior environmental costs** can be achieved by moving more data to lower-tiered solutions. On average, lower tiers will present improved:
 - a) TB-per-kWatt
 - b) TB-per-square meter of data center floor space
 - c) TB-per-kBTU of cooling

- 
- 4) **Reduced cost of waste:** When properly applied, capacity planning and LUN sizing are used in an integrated multitiered storage environment to reduce the cost of waste by moving less business critical applications and storage pools to a lower tier. IT managers may not be able to dramatically change the aggregate rate of storage utilization, but the cost of stranded LUNs or capacity can be relegated to a lower tier. This shifting can produce positive OPEX savings by minimizing the cost of waste. Focusing limited IT resources on improving utilization on higher storage tiers will provide relatively greater savings than directing those resources toward lower-tiered, less costly storage.
 - 5) **Reduced cost of management:** Since not all data, applications and storage resources are created equal, the labor effort applied to storage tiers does not need to be equal either. Lower-tiered applications will have relatively fewer labor (management, provisioning, sizing, reporting) efforts assigned. Scarce labor resources can be saved and used for managing the more critical areas of the storage infrastructure.
 - 6) Many storage **infrastructure resources** can be aligned properly to the service and storage tier necessary. This alignment can limit external resources (software fees, circuits) to protect necessary data/tiers as defined by the business. Some infrastructure resources that can be reduced (in the aggregate) have been found to include:
 - a) Software licenses and software maintenance fees
 - b) Long distance network circuits for replication, data movement
 - c) Disaster recovery services and resources
 - d) Tape resources, library space
 - 7) Reducing the **storage procurement time** can be a valuable byproduct of multitiered storage, especially as unplanned capacity requests can be provisioned in lower storage tiers. Business wait time can be minimized and procurement cycles can be used to plan for critical upgrades and planned growth patterns.

Many of these above areas are defined in the following sections of this paper, and calculation parameters and determination and qualification methodologies are summarized. Cost reduction logic and calculation methods outlined in this paper apply to large storage installations, as well as smaller sites. Naturally, the larger the total storage environment, the more opportunities may exist to reduce costs and waste and provide added efficiencies.

TCO Reduction and Calculation Details of Tiered Storage

The next five sections outline the cost reduction opportunities enabled by multitiered storage architectures. More than just five OPEX or CAPEX areas are impacted by this new architecture, but these areas have been observed in real world situations, with proofs and calculation techniques documented.

Lower Cost of Growth

Tiered storage can enable the right applications to be on the right media for current and future access requirements. Since the tiers of storage represent various services levels and costs, the function of stratifying storage capacities among lower-cost tiers (as opposed to a single, higher-cost tier) will result in less CAPEX spending in upcoming years. Besides CAPEX cost reduction, other cost factors associated with total cost of storage are also reduced. Storage analysts and Hitachi Data Systems' own observation is that that purchase price is one-seventh of the TCO; therefore, any capital purchase avoided will also impact downstream OPEX.

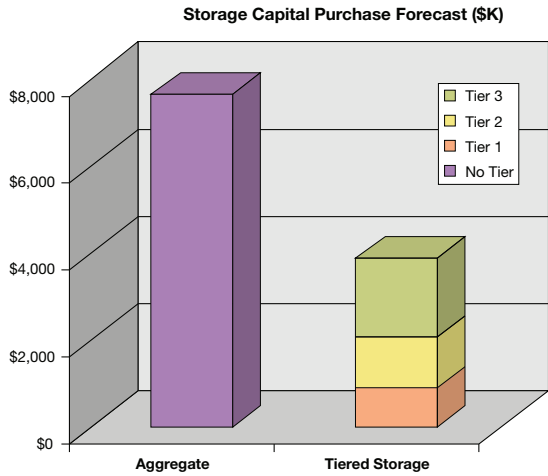
In single-tiered storage architectures, all data is stored in one pool and purchased at one general rate. The expected growth rate is applied uniformly to all applications and data in the single pool. Future growth plans and forecasts are also done with one price erosion point for all data. As shown in Table 1, with multitiered storage, costs and price erosion factor are leveraged or spread between multiple tiers, thus reducing CAPEX costs over the short term.

Table 1. Single Storage Pool versus Multiple Storage Tier Comparison

Category	One Storage Pool	Multiple Tiers of Storage
Pools or Tiers	One standard for all data storage	Two to five tiers of storage, matched to the applications: Highest tier for critical applications Middle tier for everyday applications Lower tier for archive, tape replacement
Cost	One base rate for all storage	Higher-cost disk for limited number of applications Moderate-cost disk for majority of applications Low-cost disk for archive, backups, etc.
Price Erosion	One base rate for all storage	Moderate erosion for higher tier High erosion rate for middle tiers Very high erosion rate for lowest tiers
Growth Rate	A blended growth plan, usually for the worst-case projects	Rates of growth and capacity — planned by tier or category of applications: <ul style="list-style-type: none"> • Higher tiers tending to be more stable, and therefore slower growth • Middle tiers tending to have higher growth • Lower tiers can have often erratic growth

By stratifying data and putting the erratic growth forecasts into lower-cost tiers, the aggregate purchase plan for disks will be less. Even with higher rates of waste in the lower tiers, the price per GB is so significantly less with a tier 3 or 4 compared to tier 1, that the capital purchase savings can be extraordinary. Figure 3 demonstrates a three-year CAPEX plan comparing the same total purchase capacity, the only difference being the capacities are split into three tiers as compared to a single-tiered architecture. Not all CAPEX comparisons may show a 50 percent drop in storage CAPEX as the example depicts, but achieving 20 to 50 percent CAPEX reduction over two to three years is not uncommon.

Figure 3. Three-year CAPEX Plan – The Difference in Tiered Growth versus Monolithic Growth



Achieving 20 to 50 percent CAPEX reduction over two to three years is not uncommon.

Calculating Cost of Growth Savings

The calculation is very straightforward if the current purchase plan and future capacity growth plan is known.

Step 1: Determine both a single tier and multitier capacity growth plan. In the Table 2 example the cumulative capacity for both single tier and multitiered growth is the same. We are not going to change the total growth appetite with tiered storage, just the cost of the growth.

Table 2. Re-allocating the Future Growth with Tiers

<i>Additional Growth Plans</i>				
Tier Type	Current Allocation	Year 1	Year 2	Year 3
Single Tier	100TB	20TB	20TB	30TB
Cumulative Capacity		120TB	140TB	170TB
Multitiered Storage Tier 1	20TB	2TB	3TB	5TB
Multitiered Storage Tier 2	40TB	8TB	7TB	10TB
Multitiered Storage Tier 3	40TB	10TB	10TB	15TB
Cumulative Capacity	100TB	120TB	140TB	170TB

Step 2: Determine both a single tier and multitier price-per-TB and the price erosion factor.

Table 3. Determining Price per TB

<i>Tier Type</i>	<i>Price per TB Today</i>	<i>Yearly Price Erosion</i>
Single Tier	\$16,000	20%
Multitiered Storage Tier 1	\$16,000	20%
Multitiered Storage Tier 2	\$10,000	25%
Multitiered Storage Tier 3	\$4,000	30%

Tiered Price and Cost Ratio

Over the past several years, some patterns have emerged relative to a distribution ratio of price and cost for tiered storage. Ideally, formal design and cost characterization efforts would produce the right cost results for each tier. For planning purposes, though a “prime number ratio” is helpful in making preliminary plans for the cost per tier. In a 4-tiered model the price or cost ratio is 11:7:3:1. In a 3-tiered model, the ratio would tend to be 7:3:1.

Step 3: With a simple spreadsheet calculation, the CAPEX forecast for the future growth of each year can be calculated.

Table 4. Determining the CAPEX Forecast to Fund Three Years of Growth

<i>Forecast Storage CAPEX – Three Tiers</i>	<i>Year 1</i>	<i>Year 2</i>	<i>Year 3</i>
Cost of growth in a single tier architecture	\$256,000	\$204,800	\$245,760
Cost of growth with multitiered storage	\$113,600	\$89,695	\$103,728
Delta CAPEX = procurement savings	\$142,400	\$115,105	\$142,033

Step 4: The total CAPEX savings is the difference of the single tier versus the multitiered storage solution over three years. In this case the difference is \$399,538.

Sweat the Assets

A secondary cost savings observation from multitiered storage architectures is achieved by extending the useful life of older or existing assets. This cost saving factor is achieved by virtualization technology and is covered in the Hitachi Data Systems white paper “Storage Economics: Hitachi Universal Storage Platform” (http://www.hds.com/pdf/wp_197_storage_econ_usp.pdf). The relevance here is that through virtualization, older storage systems can be relegated to lower-tiered storage pools in multitiered storage architecture. These assets are often fully depreciated, may still have several years of useful life and may be seen as virtually free storage capacity. Some may be on maintenance, other resources may not be. With careful consideration of maintenance cost versus replacement costs, many older storage systems can still be used for data storage that is not critical, or impacted by periods of outages (due to maintenance or repair). Older storage systems still have RAID protection, but the balance of outages due to equipment being off of maintenance would have to be factored properly into the usage plans.

Placing older/depreciated assets behind an intelligent storage controller like the Universal Storage Platform can provide the data migration, data management and storage access presented in a uniform manner to the enterprise. Software costs on the older storage systems will not be needed, since the intelligent controller will manage the lower-tiered storage automatically.

There is a legitimate aspect/warning about sweating IT assets, or using very old storage systems in a tiered environment. Even though the disk may be depreciated, it is not free to own and operate. Time and Material maintenance costs are usually higher after the warranty period, plus the power cooling required in many cases makes this storage economically unattractive. Calculations of TB-per-kWatt or TB-per-square meter can help comparisons of older storage versus a refresh or replacement approach.

Improving Aggregate Utilization

With data prepared and stored on different tiers of storage, several disk parameters can be applied to meet the individual storage needs of each tier. These various parameters are demonstrated in the sample tiered architecture outlined in the appendix section of this paper. Some of the parameters that can be altered are the LUN size and RAID level presented for the storage. Presentation of different LUN sizes and better mapping of storage resources can yield better overall utilization of allocated storage resources for different applications. Hitachi Data Systems has observed several specific application-based optimization schemes that improved utilization. As these concepts are applied for more applications and the enterprise, aggregate utilization of storage becomes dramatic, and verifiable.

Another aspect of improving storage utilization is shown in the effect of moving applications that tend to produce stranded capacity (within the LUNs or volumes) to lower-tiered storage, so as to reduce the resulting cost of storage waste. In a multitiered storage architecture, unforecast storage capacity can be allocated to a lower tier of storage (an implied penalty for not being in the forecast); typically unforecast applications or systems tend to have poor utilization.

Utilization rates vary from company to company and are different between operating systems (host types), application types and geographies. Table 5 demonstrates the effect of one tier of storage in one frame, or in multiple frames. With a multitiered storage architecture, the utilization rates can see a slight increase within a single frame, but demonstrate a large utilization jump when designed with multiple frames, tightly integrated with management tools and virtualization concepts.

Table 5. Target Utilization Rates

	<i>One Tier</i>	<i>Multiple Tiers</i>
Multiple Frames	25–40%	60–80%
One Frame	40–50%	45–55%

Calculating Potential Cost of Waste

The calculation is very straightforward if the current utilization rates and price-per-GB of storage is known (see Table 6).

Step 1: Determine the single-tier utilization rate for the storage infrastructure. Industry averages show that Windows can be 28–32 percent, UNIX is in the 35–45 percent range, and MVS and z/OS are in the 60 percent range.

Example: 250TB, single-tiered architecture with an aggregate utilization of 50 percent. Price per usable TB is \$12,000.

- Cost of waste is (capacity x waste level) x price/TB
- Cost of waste is (250TB x 50 percent) x \$12000
- Cost of single-tiered storage waste is \$1,500,000

Step 2: Define a multitiered architecture, planning for tighter management and capacity planning for higher tiers, and more relaxed plans or utilization for lower tiers. Lower tiers of storage are cheaper to purchase, so the cost of waste is minimized as application capacities are spread between the multiple tiers.

Table 6. Cost of Waste

	<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 3</i>	<i>Tier 4</i>
Total Capacity TB	25	50	75	100
Utilization Target	80%	70%	50%	40%
Cost per TB	\$12,000	\$9,500	\$7,000	\$5,000
Cost of Waste	\$60,000	\$142,500	\$262,500	\$300,000
Aggregate Cost of Waste				\$765,000

Step 3: The differences in the cost of waste in this example of 250TB is \$735,000. This money can be seen as reducing the future CAPEX budget through better asset utilization.

Reducing Labor Cost

With different tiers of storage, differing levels of management effort can be applied to be commensurate with the value and use of the data on each tier. With small-to-medium environments (less than 100TB), a significant reduction in labor cost may be negligible. For larger environments, different service levels and operating levels can be applied for different levels of labor content. Some of the labor activities that can be directly impacted by storage in a multitiered storage architecture include:

- Storage provisioning time
- Management and labor effort

- Backup support, including recovery time and snap copy management
- Operational control and monitoring

In a single pooled environment, the data value is hard to segregate, so everything is managed in a uniform manner (relative to labor efforts). Provisioning is about the same, and problem resolution and event handling is also uniform since an error may impact critical and non-critical applications alike. In a multitiered architecture, different levels of support and proactive management time can be properly allocated, as shown in Table 7.

Table 7. Multitiered Storage Architecture Support and Management Time

	<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 3</i>
TB per Person	25	50	100
Mean Time to Provision (includes purchase, install, configure, allocate)	Months	Weeks	Days
Mean Time to Respond to Problems	Hours	Days	Best Effort

With multitiered storage, the applications and data can be split between multiple pools (our example here is 3), with administration efforts applied at different rates, depending on the pool. Tier 1 resources are managed more closely, with more labor effort for optimization, protection, performance, etc. Response time is different for each tier, with SLA and problem responses also very different. Provisioning time is different as well, so that higher-tier storage purchases are done in bulk and less frequently (and according to capacity plan). Lower-tier storage capacity can be provisioned faster, since there may be more headroom capacity already in the storage systems, waiting to be allocated. Remember that the lower tiers tend to have low average utilization, so there is space available for rapid provisioning.

The differences of labor needed to support various architectures can be estimated based on the TB-per-person metric. With large environments, seven- to ten-percent labor impact/effectiveness has been observed with storage teams that implement tiered storage architecture.

Data Protection/Disaster Protection

This paper has presented the idea that all data, storage and hosts are not created equal, and that the tiering of these services can reduce cost. This same concept applies to proving different levels of data protection and disaster protection to align these costs with the value to the business.

Pooling various storage tiers behind a single, intelligent storage controller can reduce storage infrastructure required for the environment. Tiered architecture can define data protection infrastructures to be segmented and those that exist behind the storage pools, and with intelligent controller-based virtualization it can impact data recovery, replication and disaster recovery costs.

The previous sections have already described some of the cost reduction or avoidance options with tiered data and network connections (see Table 8 for summary). The following use case is similar since different tiers of storage can be designed with different replication paths, processes, hardware and software investments, etc. Typically, only data stored on higher tiers would demand high-protection schemes, so the cost of data protection and disaster recovery can be limited to a smaller set of data pools, rather than the entire storage infrastructure. In the previous chapters, tiered storage solutions have relegated only 10 to 20 percent of the storage assets to the highest storage tier. This level would require the most protection. Subsequent lower tiers could see a reduction in the disaster and data protection schemes that are put into place, due to the reduced criticality of these lower pools.

Table 8. Considering Cost Impact after Employing Tiered Storage

	<i>Before</i>	<i>After</i>	<i>Difference</i>	<i>Cost Impact</i>
Remote-site Circuits	4	1	3	\$ per month circuit lease
DWDM, IP Gateways	12	4	8	\$ per device

Except for the highest levels of tiered storage, storage architects can reduce the investment and infrastructure for lower-tiered storage pools. Cost savings can be calculated from a variety of sources:

- Replication software that will not be necessary for 60 to 80 percent of the storage capacity
- Purchase price is less
- Monthly license fees, maintenance costs reduced
- Training costs eliminated
- Maintenance and labor costs related to scripting
- Backup servers (nodes) can be altered
- Tape devices, libraries can be right sized
- IP infrastructure needed for backups can be right sized
- Total space needed for snap copies, volume copies, remote (asynchronous or synchronous) copies can be mapped closer to the total capacity that needs this type of protection

As the data protection infrastructure is aligned and optimized for only the higher tiers of storage, the excess investments for the remaining storage capacities can be eliminated or greatly reduced.

Conclusion

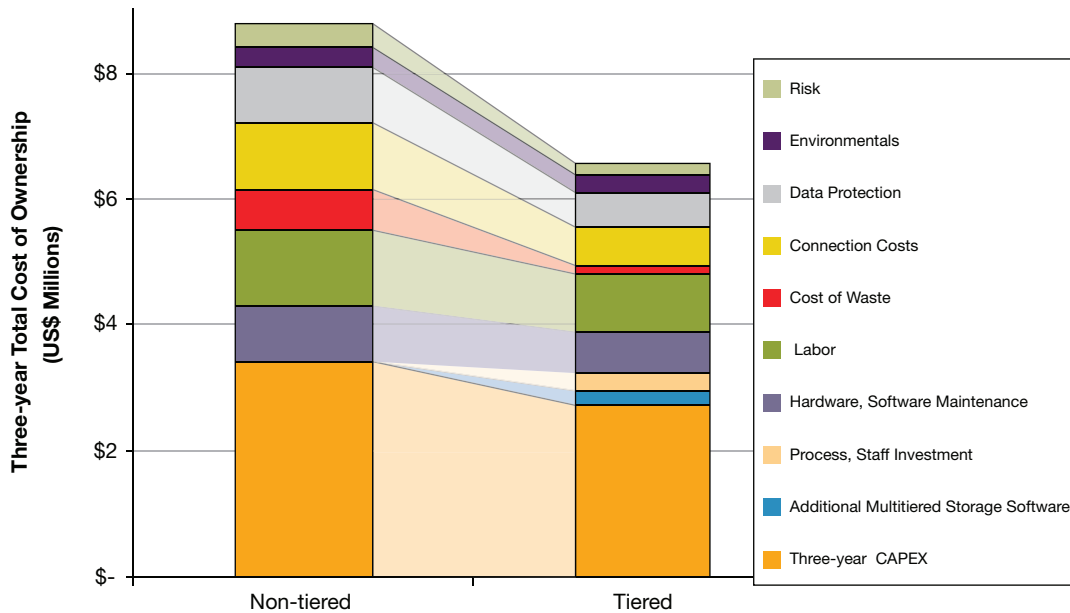
IT and storage architects have been testing and implementing tiered storage and storage virtualization architecture to meet application and technical performance criteria. Now tiered storage can be proven to reduce current and future CAPEX costs, as well as operational costs. Tiered storage, as a storage initiative, has been proven to reduce operating and ownership costs for medium and large storage enterprises.

With the theorems and proof points documented in this paper, a new cost model for storage can be developed that can significantly reduce the TCO. Using some of the five points outlined above, along with other ownership cost elements (that may not be impacted by multitiered storage), a multiyear ownership comparison provides additional help in justifying a new tiered architecture.

Figure 4 summarizes three-year costs, broken into several CAPEX and OPEX categories, for a large storage infrastructure. Multitiered storage does contribute to the reduction of costs, by a difference of 24 percent in this example, in the areas of:

- Capital purchases
- Labor
- Cost of waste
- Data protection
- Storage infrastructure

Figure 4. Three-year TCO Comparison



Multitiered storage contributes to the reduction of costs by 24 percent.

Note also that there are some offsetting costs associated with multitiered storage, such as additional training, process development, storage management and software in order to facilitate this new architecture.

As IT departments and storage planners continue to look at best practices and technologies to proactively reduce ownership costs, a tiered storage approach should be investigated and presented as a viable option for future storage strategies. Long-term costs and current costs can be significantly altered by properly designing and implementing some of these multitiered storage concepts.

Appendix A: Sample Tiered Storage Architecture

Appendix A Table 1 examines how the storage infrastructure, not just the storage systems, can be segregated into tiers of services. Tiered approaches for storage, connection, backup, data protection and disaster recovery are blended into this single table. Hitachi Data Systems consultants often see an à la carte method for providing variety of infrastructure services to meet all the business needs.

Appendix A Table 1. Hitachi Data Systems Sample Three-tiered Storage Catalog

	Tier 1	Tier 2	Tier 3
Data Type	Operational	Application	Referential
Applications	Mission critical	Business important	Archive, retention
Overall Availability	99.999%	>99.99%	>99%
TCO-per-TB per Year	\$40,000	\$33,000	\$20,000
I/O Performance	Highest	High	Medium
Aggregate I/O Rates	Up to 500,000	Up to 250,000	Up to 100,000
Disk Type (typical)	146GB, 15,000RPM	300GB Fibre Channel 10,000RPM	750GB SATA
RAID	RAID-1+0 Mirroring	3+1 RAID-5	RAID-6
Planned Downtime	None	2 hours/year	10 hours/year
Backup Media	Disk	Disk	Disk, VTS
Backup RPO	<4 hours	<24 hours	<7 days
Backup RTO	1 day	3 days	Best effort
Replication	Yes	On demand	None
Local Snap Copies	On-demand	None	None
Connection	Dual-path Fibre Channel	Single-path Fibre Channel	IP (NAS, iSCSI)
Storage-port Ratio	Very low	Medium	High
Mean Time to Provision	Weeks	Days	Hours
Problem Response	<2 hours	<4 hours	Best effort
Disaster Protection	Necessary	In limited cases	None

 **Hitachi Data Systems Corporation**

Corporate Headquarters 750 Central Expressway, Santa Clara, California 95050-2627 USA
Contact Information: + 1 408 970 1000 www.hds.com / info@hds.com!

Asia Pacific and Americas 750 Central Expressway, Santa Clara, California 95050-2627 USA!
Contact Information: + 1 408 970 1000 www.hds.com / info@hds.com !

Europe Headquarters Sefton Park, Stoke Poges, Buckinghamshire SL2 4HD United Kingdom
Contact Information: + 44 (0) 1753 618000 www.hds.com / info.uk@hds.com!

Hitachi is a registered trademark of Hitachi, Ltd., and/or its affiliates in the United States and other countries. Hitachi Data Systems is a registered trademark and service mark of Hitachi, Ltd., in the United States and other countries.

Universal Storage Platform is a trademark of Hitachi Data Systems Corporation.

IBM, MVS, z/OS, FICON and ESCON are registered trademarks of International Business Machines Corporation.

Microsoft is a registered trademark of Microsoft Corporation.

All other trademarks, service marks and company names are properties of their respective owners.

Notice: This document is for informational purposes only, and does not set forth any warranty, express or implied, concerning any equipment or service offered or to be offered by Hitachi Data Systems. This document describes some capabilities that are conditioned on a maintenance contract with Hitachi Data Systems being in effect, and that may be configuration-dependent, and features that may not be currently available. Contact your local Hitachi Data Systems sales office for information on feature and product availability.

Hitachi Data Systems sells and licenses its products subject to certain terms and conditions, including limited warranties. To see a copy of these terms and conditions prior to purchase or license, please go to <http://www.hds.com/corporate/legal/index.html> or call your local sales representative to obtain a printed copy. If you purchase or license the product, you are deemed to have accepted these terms and conditions.

© Hitachi Data Systems Corporation 2008. All Rights Reserved.
WHP-203-01 LKW April 2008